GARLAND (G. M.)



# SOME EXPERIMENTS UPON THE CURVED LINE OF DULNESS WITH PLEURITIC EFFUSION.

By G. M. Garland, M.D.

It occurred to me that, if a fluid capable of setting could be injected into the pleural cavity of an animal, it would subsequently admit of exposure by dissection without disturbance of the mutual relation of lung and effusion, and thereby aid in interpreting the mysterious writing on the wall.

With the kind assistance of Prof. H. P. Bowditch, I therefore began a series of experiments upon dogs, in his laboratory. The results obtained are not as complete and satisfactory as might be desired, but my apology is that my time is too limited by other engagements for more complete investigation of the subject at present.

We employed, in our experiments, several forms of glue and gelatine, with chromate of potash as a hardening agent. Mutton suet and plaster of Paris were also used. The plaster of Paris gave the most satisfaction, but required great expedition in preparing and injecting it, as it set so quickly. It was mixed with water to a thick fluid consistence, and was then poured into a glass flask. This flask was arranged like a common wash-bottle. The air within it was condensed by pressure from a rubber bulb, and this condensed air drove the fluid through a rubber tube connected with a canula in the dog's side.

One or two of the early experiments were aborted by the admission of air into the chest. The air allowed the lungs to collapse, and the injection assumed a hydrostatic level.

To avoid this casualty, we chose a region where the canula could be boldly plunged through the chest-walls with least danger to the contained viscera. During full inspiration, the lungs occupy all the thoracic space which is accessible to them. With expiration they contract, allowing the upper surface of the diaphragm to come in contact with the thoracic walls for some distance above its line of attachment.

The canula, previously filled with water retained by a stop-cock, was plunged into this space between the ninth and tenth or the tenth and eleventh ribs in the axillary line. By inserting the finger through a small opening in the abdominal wall, the canula could be felt sliding along above the diaphragm. Its blunt end prevented accident, while, by its conical shape, it plugged the opening it made in passing through the muscles as it entered.

Actual measurement of the amount injected each time was not made, inasmuch as this point could be of value only by comparison with a

thorax of fixed size. No two of the dogs were of the same size. The injections, therefore, are merely designated small, medium or large. Both dead and etherized living dogs were injected, with no difference in the results.

After allowing time for the setting, the skin of the animal was removed and the chest carefully percussed and outlined. (See Figures 1 and 2.) The thorax was then opened, and the external line of dulness compared with the internal condition of affairs.

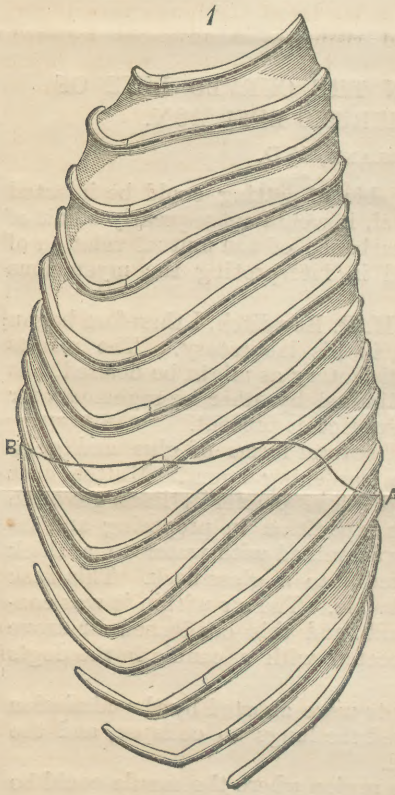


FIG. 1.
A B represents the simplest form of a curve. The effusion was small.
A is opposite the eleventh rib on the back.

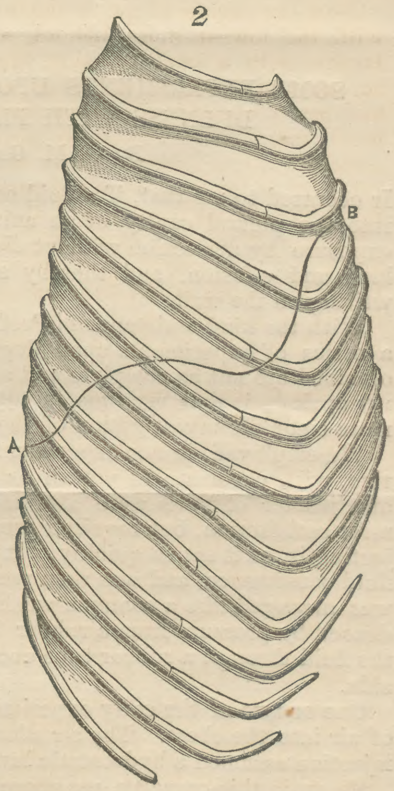


FIG. 2.
A B represents a curve of a somewhat larger effusion. The sudden rise of the curve, as it approached the sternum, was found to be partially due to a displacement of the heart by an injection in the opposite chest.

The first point which our experiments demonstrated with regard to the mutual relation of lungs and effusions is that the *resisting lung*, rather than the encroaching fluid, is the chief moulding agent and factor in determining the curve of dulness. In every instance, the lungs were practically unaltered in their gross anatomical shape, though of necessity compressed and occupying less room.

The edges of the lungs, even, were not rolled in, as the moulds show for themselves. With forcible inflation of the lungs, these bor-

ders act like wedges in cleaving the mould asunder. With the largest effusions, the lungs were approximated to the fœtal condition of atelectasis, but with form intact.

The first effect of a small effusion was to swing the lungs upon the large bronchi as hinges, *upward* and *outward* against the walls of the chest. Little or no fluid separated the lungs from the chest. It was only in cases of very large effusions, or of concurrent pneumo-thorax, that such separation occurred.

Now the normal shape of the lower border of the lungs is a curve, with the lowest point behind, and rising as it advances forward. Hence, with a small effusion, the fluid being moulded to the lower surface and border of the lungs, as I have stated, the curve is simple and easily understood. [See figure.] Internally, between lung and heart, there seemed to be the point of least resistance to the fluid, which here found an escape by shooting up some distance. The actual pressure of the lung upon the surface of the fluid was sufficient to sustain a considerable column of the effusion in this region.

Larger effusions, I have said, gradually crept in between chest-wall and lung. The curve must, therefore, be necessarily modified according to the depth of the intervening fluid, i. e., according to the relative ability of the different portions of the lung to resist lateral pressure and retain sufficient air to be resonant. This requires further investigation. Wintrich says the curve is always highest *behind*, and thence declines to the median line in front. Dr. Ellis finds, however, that the line of dulness is *lowest behind*, rises on the sides, and sinks again in front. We found, with small and medium effusions in dogs, that the curve and lung were *lowest behind*. Thence the curve rose till it reached the side, whence it proceeded, nearly horizontally, to the sternum.

The borders of the lung overlap the effusion somewhat, i. e., wedge themselves in between chest and fluid.

We made but one injection in the human body, and that in an infant a few days old. Unfortunately, we neglected to percuss the chest and note the curve, but the experiment was so far successful as to convince us that the principle of the lung moulding the effusion was the same in the child as in the dogs.

I have insisted upon the lungs moulding the fluid, because it seems to me to be the most important factor. I do not deny that the lungs may, in turn, be moulded by the effusion to some extent. It may be true with human lungs. It did not appear prominently with the dogs.

I content myself with stating what we saw, without attempting any theory why, how, or with what force, the lungs oppose the effusion. I hope, at some future time, to have an opportunity to renew these experiments upon the human cadaver, and note the modifications of different positions of the body upon the relation of the parts. Such observations might throw more light upon the conditions already seen and described.

Incidentally to the injection of living dogs, we observed the following facts, which are of some interest.

The dog's breathing, which had been more or less diaphragmatic, became purely thoracic immediately on the injection of the fluid. On opening the abdomen after the injection, the diaphragm was found bagged down like a lobster net. With each act of inspiration, however, it could be felt to rise, being drawn upward by the separation of its points of

attachment. The fluid could also be felt shifting its form and level with every act of respiration, thereby accommodating itself to each change in its containing vessel. That this movement of the diaphragm was purely a passive one, was demonstrated by grasping the muscle tightly between two fingers. It was perfectly limp and passive, devoid of muscular action.

It was suggested that, in such an abnormal position, if the diaphragm should by any means contract, it would, of necessity, act as an expiratory muscle rather than an inspiratory one, as it normally does. To demonstrate this point, we dissected out the phrenic nerve in the neck, and irritated it by electricity just above its entrance into the chest.

Before injection, such irritation always produced a violent act of inspiration, followed either by a tonic spasm of the chest-muscles or by rapid irregular breathing during the continuance of the irritation.

The same irritation of the nerve, after the injection, produced a violent act of expiration. It is evident that, with the muscle bagging down, contraction of its fibres must draw the dependent portion upward, and thus produce the phenomenon described.

I conclude that, with effusions in the chest, the diaphragm must play a passive or contradictory part.

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